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Transmission of Rec. ITU-R BO.1294 System B Transport 1.0

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Abstract:
This specification defines packetization and transmission of the transport streams for Recommendation ITU-R BO.1294 System B, which is known as a DirecTV/DSS system over IEEE Std. 1394-1995. The transmission scheme is similar to the MPEG2 transmission over IEEE std. 1394-1995, but designed for 130bytes DirecTV/DSS transport packet.

Keywords:
Audio, Video, 1394, Digital, Interface, DirecTV, DSS.

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1. Overview

1.1 Purpose

This specification defines packetization and transmission for transport streams of Recommendation ITU-R BO.1294 system B (DirecTV system/DSS) over IEEE Std. 1394-1995.

In this document, the name “DSS” is used instead of “Recommendation ITU-R BO.1294 system B”.

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2. References

The following standards contain provisions, which through reference in this document constitute provisions of this standard. All the standards listed are normative references. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below.

[R1] IEEE Std 1394-1995, Standard for a High Performance Serial Bus.

[R2] IEC 61883-1, Consumer audio/video equipment – Digital interface – Part 1: General.

[R3] IEC 61883-4: Consumer audio/video equipment - Digital interface - Part 4: MPEG2-TS data transmission

[R4] Recommendation ITU-R BO.1294, Common Functional Requirements for the Reception of Digital Multiprogramme Television Emissions by Satellites Operating in the 11/12 GHz Frequency Range, 1997

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3. Definitions

3.1 Conformance Levels

3.1.1 expected: A key word used to describe the behavior of the hardware or software in the design models *assumed* by this Specification. Other hardware and software design models may also be implemented.

3.1.2 may: A key word that indicates flexibility of choice with *no implied preference*.

3.1.3 shall: A key word indicating a mandatory requirement. Designers are *required* to implement all such mandatory requirements.

3.1.4 should: A key word indicating flexibility of choice with a strongly preferred alternative. Equivalent to the phrase *is recommended*.

3.1.5 reserved fields: A set of bits within a data structure that are defined in this specification as reserved, and are not otherwise used. Implementations of this specification shall zero these fields. Future revisions of this specification, however, may define their usage.

3.1.6 reserved values: A set of values for a field that are defined in this specification as reserved, and are not otherwise used. Implementations of this specification shall not generate these values for the field. Future revisions of this specification, however, may define their usage.

NOTE —The IEEE is investigating whether the “may, shall, should” and possibly “expected” terms will be formally defined by IEEE. If and when this occurs, draft editors should obtain their conformance definitions from the latest IEEE style document.

3.2 Glossary of Terms

3.2.1 byte: Eight bits of data, used as a synonym for octet.

3.2.2 CSR Architecture: A convenient abbreviation of the following reference (see clause 2): ISO/IEC 13213 : 1994 [ANSI/IEEE Std 1212, 1994 Edition], Information Technology—Microprocessor systems—Control and Status Register (CSR) Architecture for Microcomputer Buses.

3.2.3 quadlet: Four bytes of data.

3.3 Acronyms and Abbreviations

AV/C	Audio Video Control
CIP	Common Isochronous Packet
CTR	Cycle Time Register.
HD	High Definition
IEEE	The Institute of Electrical and Electronics Engineers, Inc.
MPEG	Motion Picture Expert Group
TSP	Transport Stream Package

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4. DSS Transport Stream

A DSS transport stream consists of transport stream packets with a length of 130 bytes.

Refer to Appendix 1 to Annex 1 of reference [R4], "System B transport stream characteristics", for more information.

A stream may contain several programs. In Figure 4.1, an example is given of a transport stream, which consists of several programs. Often, only one or a few programs need to be transmitted. If a program selection is carried out, then only those transport stream packets from that particular transport stream are transmitted. In this situation, the occupied bandwidth on the 1394 interface can be reduced. Reduction of the bit rate is carried in a smoothing buffer. As a result of the smoothing operation, the transport stream packets will be shifted in time.

The transport stream packets at the output of the smoothing buffer are transmitted over the 1394 interface. During transmission, this interface will introduce some jitter on the arrival time of the transport stream packets in the receiver.

In the DSS transport stream, there are strong requirements on the timing of the transport stream packets. The jitter introduced by the both the smoothing buffer and the transmitter of the interface must be compensated. This is done by adding a time stamp to the transport stream packets

- at the moment it arrives at the input of the smoothing buffer, or
- at the input of the digital interface, if smoothing is not applied

The receiver of the interface contains a receiver buffer, which compensates for the introduced jitter.

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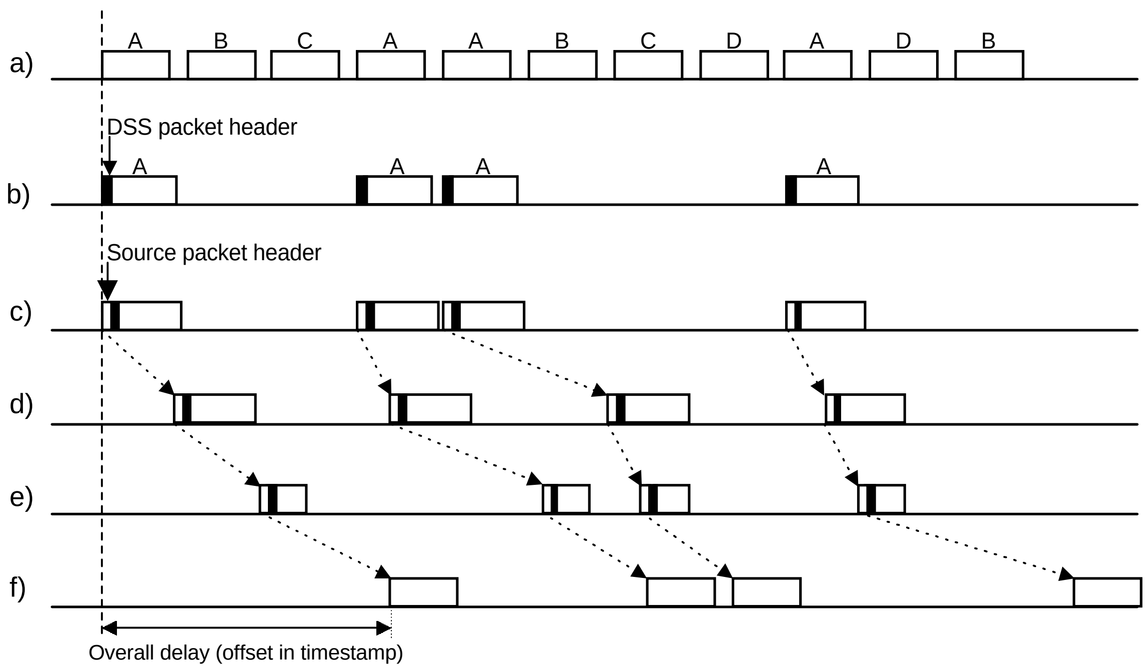

a) Complete transport stream with multiplex of programs (A,B,C,D)
b) Transport stream of the selected program A with DSS packet header (=DSS source packets)
c) Source packets with source packet header
d) Source packets at the output of the smoothing buffer
e) Source packets at the input of the 1394 receiver
f) Reconstructed timing for the transport stream

NOTE: The clock frequency for transferring the bytes of a transport stream packet may be different in eve
situation

Figure 4.1 – Steps in the transmission of transport stream

The following figure shows how the DSS stream is processed between the original multiplex signal, the 1394 interface, and the decoder.

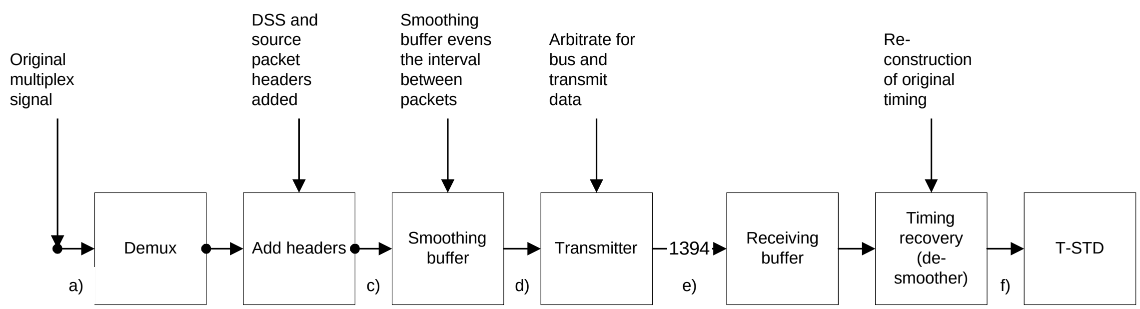

Figure 4.2 – DSS stream processing block diagram

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5. Construction of a 1394 Packet

5.1 Source Packets

5.1.1 Structure of a Source Packet

The length of the source packet is 140 bytes as shown in Figure 5.1. The source packet consists of one DSS transport stream packet with a length of 130 bytes and a DSS packet header of 10 bytes.

The source packet header is additionally added before transmitted to the smoothing buffer. The source packet header contains a time stamp.

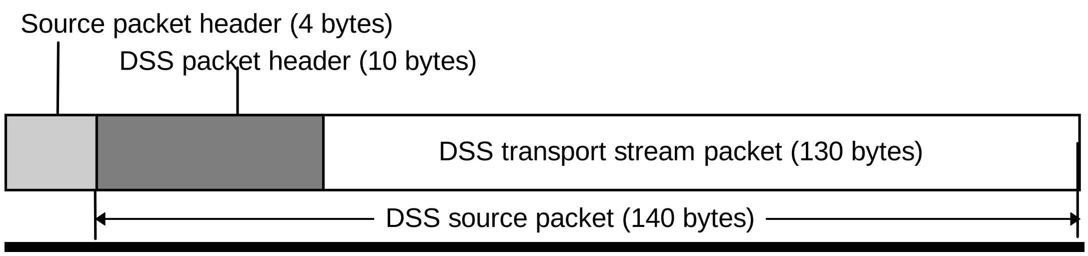

Figure 5.1 – Structure of a source packet

5.1.2 DSS Packet Header

Figure 5.2 shows the structure of DSS packet header.

	msb							lsb
MSB	SIF	System Clock Count (23bit)						
	EF	Reserved (0000000_2)						
	Reserved byte 0 (00_{16})							
	Reserved byte 1 (00_{16})							
	Reserved byte 2 (00_{16})							
	Reserved byte 3 (00_{16}) Reserved byte 4 (00_{16})							
LSB	Reserved byte 5 (00_{16})							

Figure 5.2 – DSS packet header structure

The DSS packet header contains the following.

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Table 5.1 – Fields in the DSS Packet Header

Field	Definition
SIF	System clock count Invalid Flag (1: invalid, 0: valid)
System clock count (23 bits)	A 23 bit field that is set to the lowest 23 bits of the 27MHz clock counter, which is synchronized with MPEG system clock. The value of this counter may be different from the byte time stamp counter used to generate the byte time stamp in the auxiliary data packet (defined in 4.1 of Appendix 1 of Annex 1 in [R4]).
EF	Error Flag (1: Error, 0: no Error) Set to value 1 when the associated transport stream packet is erroneous

The system clock count is used by bit stream recorders, like DVHS, to lock its system clock phase to the source stream without needing to look into the DSS transport stream packet for clock information. If a stream contains video and/or audio application packets, then the stream shall contain packets with a valid system clock count. The maximum interval between valid system clock counts (or "ticks") shall be 200ms. Therefore many audio and video packets in between may not contain a valid system clock count.

If a stream does not contain video or audio application packets, then the system clock count is not required.

5.1.3 Source Packet Header

Figure 5.3 shows the structure of the source packet header.

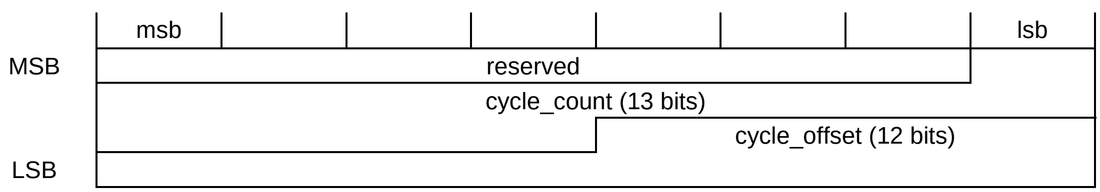

Figure 5.3 – Structure of the source packet header

The reserved bits are zero. The cycle_count and cycle_offset fields represent a time stamp.

The time stamp is used by isochronous data receivers for reconstructing a correct timing of the transport stream packets at their output. The time stamp indicates the intended delivery time of the first bit/byte of the transport stream packets from the receiver output to the T-STD (Transport Stream Target Decoder). The time stamp represents the 25 bits of the IEEE1394 CYCLE_TIME register (CTR) at the moment the first bit/byte of the transport stream packet arrives from the application, plus an offset which is equal to the constant overall delay of the transport stream packet between the moment of arriving (of the first bit) and the moment the transport stream packet (first bit) is delivered by the receiver to the application.

5.1.4 Fractions

A source packet is split into 4 data blocks with a length of 9 quadlets. Zero or more data blocks are packed in a IEEE1394 isochronous packet. A receiver of the isochronous packets collects the data blocks of one source packet and combines them in order to reconstruct the source packet before sending this source packet to the application. There are restrictions on the transmission of fractions (5.2.2).

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5.2 Isochronous Packets

5.2.1 CIP Header for DSS Transport Stream

The structure of the CIP header (see figure 3) for DSS transport stream is compliant with the two quadlets CIP header format explained in PART 1 chapter 6.2.1 of reference [R2]. The values of the CIP header components are as follows.

Table 5.2 – Fields in the CIP Header

Field	Value	Description
SID	...	depends on configuration
DBS	00001001_2	9 quadlets
FN	10_2	4 data blocks in one source packet
QPC	000_2	no padding
SPH	1	source packet header is present
DBC	0 ... 255	see clause 5.2.2
FMT	100001_2	Format type of DSS (Recommendation ITU-R Bo.1294 System B)
FDF	.....	see clause 5.2.3

5.2.2 DBC Values

The first data block of a source packet (data block containing the source packet header) corresponds to a DBC value from which the two LSBs are $\mathbf{00}_2$.

An isochronous packet contains 0, 1, or 2 data blocks, or an integer number of source packets.

— If the isochronous packet contains :
One data block, then the DBC value increments by 1.
Two data blocks, then the DBC value is a multiple of 2, the LSB is $\mathbf{0}_2$.

— If the isochronous packet contains ***n*** source packets (***n*** is an integer) then the DBC value is a multiple of 4. The two LSBs are $\mathbf{00}_2$.

5.2.3 FDF Data

The structure of the CIP header is shown in Figure 5.4.

TSF (Timeshift_flag): Indicates a time-shifted stream

— 0 = the stream is not time-shifted

— 1 = the stream is time-shifted

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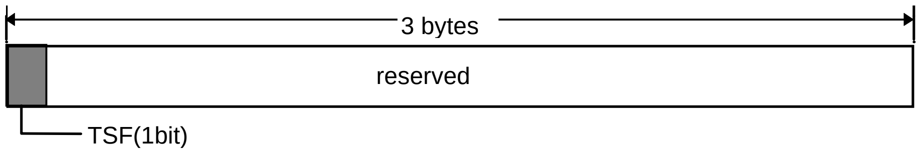

Figure 5.4 – FDF structure

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6. Transmission of Isochronous Packets

Active transmitters send an isochronous packet in every cycle. If data is insufficient to transmit in the isochronous packet, then an empty packet is transmitted.

6.1 Late Packets

The time stamp in the transmitted source packet header points to a value in the future. If the delay in the transmitter is too long and results in a time stamp which points in the past (late packet), then this source packet is not transmitted.

A late packet occurs if the actual value of the CTR becomes equal to the value represented in the time stamp from the source packet header and before transmission of the isochronous packet(s) which contain the source packet (including CRC).

— If 1 source packet/cycle is transmitted, the interval needed to transmit the complete isochronous packet can be calculated (the clock frequency and the number of bits is known). If a late packet occurs, then an empty packet or the next valid packet should be sent and the late packet is discarded.

— If more than 1 source packet /cycle is transmitted, then the same procedure is followed. It is allowed to discard all source packets from the isochronous packet if one source packet turns out to be a late packet.

— If fractions are transmitted, it is recommended to collect first a complete source packet in the transmitter.

— If a late packet occurs, then the complete source packet should be discarded.

— If a late packet occurs when some data blocks of the source packet have already been transmitted (e.g. at a bus reset), then data blocks remaining in the transmitting buffer are removed.

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Annexes

Annex A: Buffer Size for DSS Transmission

To calculate receiving buffer size, two kinds of buffers are defined.

1) Buffer for 1394 jitter, and
2) Buffer for MPEG smoothing.

There are two kinds of transmissions. Calculation is made with both cases.

1) For full transponder transport stream transmission, only a buffer for 1394 jitter is necessary since no smoothing exists.
2) For partial transport stream transmission, both a buffer for 1394 jitter and a buffer for MPEG smoothing are required.

A.1 Buffer for 1394 Jitter

The TSP packet can be sent to the application by the receiver as soon as the CRC of the isochronous packet is carried out. The buffer size needed to compensate jitter introduced by the transmitter is given by the following relation:

Buffer_size_I = (R_bus) * (max_jitter) + (B_granularity)

where,

R_bus is the allocated data rate on the IEEE1394 interface;
max_jitter is the maximum 1394_jitter (~311 µs) minus the minimum time needed to transmit one bus packet. 311µs (fixed) = 125µs (1 cycle late) + 78µs (delay by async) + 108µs (delay by iso);
one_bus_packet_time = bus packet size / 393.216 Mbps;
B_granularity is the size of one bus packet (TSP/cycle).

The necessary buffer size will be largest with high transmission rates (several TSPs per cycle) and high clock frequencies of the bus (400Mbs).

In the table below, the buffer size for jitter is given for some transmission rates:

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Table A.1 – Buffer for jitter example

Transmission rate TSP/cycle	Transmission rate Mbps	Minimum buffer size bytes
1/8	1.152	63
1/4	2.304	125
1/2	4.608	250
1	9.216	499
2	18.432	991
3	27.648	1,476
4	36.864	1,955
5	46.080	2,427

1. The buffer size above does not include the size which depends on the reading out data rate.
2. The data rate on the bus is 393.216MHz.

A.2 Buffer for MPEG Smoothing

The buffer for MPEG smoothing is defined by the equation as follows:

Buffer_size_S = (B_smoothing) + (R_bus * jitter_RTI) + (B_aux)

where

B_smoothing = 1536 bytes;
R_bus = data rate on IEEE1394;
jitter_RTI = 50µs (ISO/IEC 13818-9);
B_aux = 144 bytes as source packet.

In the table below, the MPEG smoothing buffer size is given for some transmission rates:

Table A.2 – Buffer for MPEG smoothing example

Transmission rate TSP/cycle	Transmission rate Mbps	Minimum buffer size bytes
1/8	1.152	1,687
1/4	2.304	1,694
1/2	4.608	1,709
1	9.216	1,738
2	18.432	1,795
3	27.648	1,853
4	36.864	1,910
5	46.080	1,968

1. Minimum better size needed to compensate jitter originating from the smoothing buffer (including RTI and AUX packet)

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A.3 Buffer for Full Transponder Transport Stream

The DSS full transponder data rate = 30.3Mbps < 4 TSP/cycle. Thus, using Table A.1, the smallest buffer that meets the size requirements for the data rate is 1,955 bytes.

A.4 Buffer for DSS HD Partial Transport Stream

The DSS HD partial stream data rate < 20Mbps < 3 TSP/cycle. The smallest buffer size for DSS HD requires both the buffer for jitter and the buffer for MPEG smoothing:

= Buffer_size_I + Buffer_size_S
= 1,476 bytes (from Table A.1) + 1,853 bytes (from Table A.2).
= 3,329 bytes

A.5 Conclusion

The required buffer size is determined by comparing the buffer for the full transponder transport stream and the buffer for the DSS HD partial transport stream and choosing the largest – which is 3329 bytes. Rounding up to the nearest multiple of 144, the required buffer size for a DSS Link is 3,456 bytes.

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